



ENERGY STAR Showcase Building Project

*Demonstrating Profitable Energy Savings
in Retail Establishments*



**Target Store
Fullerton, California**

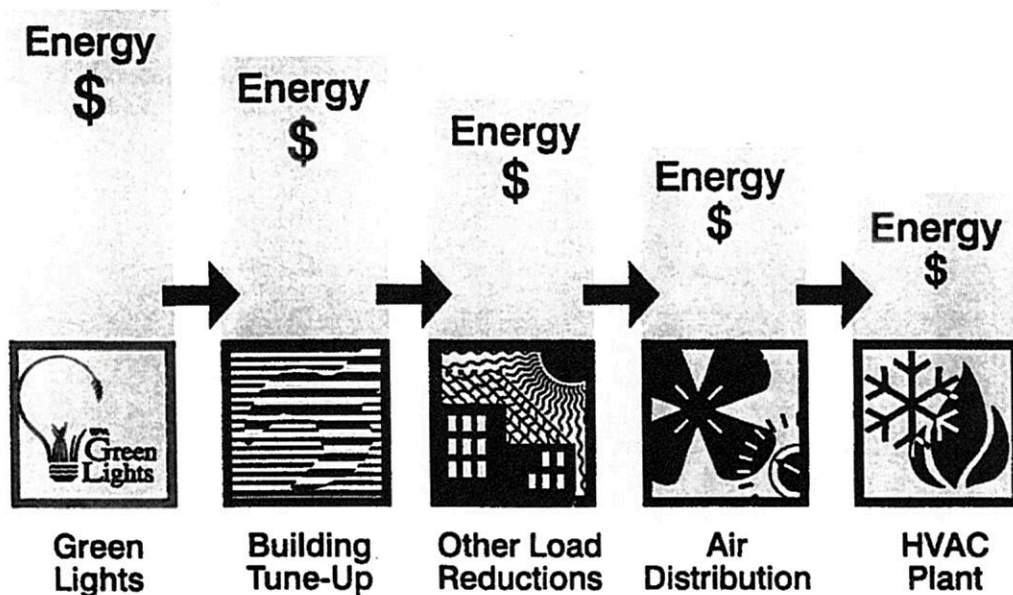


Preface

This report presents the results of a comprehensive energy-efficiency upgrade at the Target store in Fullerton, California. The Target store is one of more than 20 ENERGY STAR Showcase facilities whose owners have volunteered to pilot test the EPA's ENERGY STAR Buildings Program and verify, through monitoring and modeling, the profitable energy savings that can be gained through the Program's upgrades.

The ENERGY STAR Buildings Program is a voluntary energy-efficiency program aimed at commercial buildings. By making cost-effective energy-efficiency improvements in these buildings, ENERGY STAR Buildings participants save on energy costs and help reduce the air pollution created when fossil fuels are burned to generate electricity. Central to the Program is a five-stage upgrade strategy which takes advantage of system interactions to maximize energy savings while minimizing equipment costs. As shown below, the upgrades are sequenced so that heating and cooling loads are reduced before major HVAC upgrades are initiated. Besides providing immediate energy savings, load reductions can reduce the size and cost of upgraded HVAC equipment.

For more information about the ENERGY STAR Buildings Program or the other Showcase Building projects, call the ENERGY STAR Hotline at 1-888-STAR-YES.



Project Summary and Conclusions

Project in Brief

Actual Annual Savings:

24 percent

IRR:

20 percent

Pollution Prevented:

Carbon dioxide: 409,596 lb./yr.

Sulfur dioxide: 993 lb./yr.

Nitrogen oxides: 1,354 lb./yr.

The Target store in Fullerton, California, is one of a chain of retail stores based in Minneapolis, Minnesota. Using the staged, comprehensive ENERGY STAR Buildings approach, the 23 energy-efficiency upgrades listed in Exhibit 1 were implemented on a very compressed schedule that ended in March 1995. During the first year after the upgrades were completed, energy use at the store dropped by 24 percent.

Target has committed itself to an aggressive program to identify and implement *environmentally*

friendly design concepts and *high-efficiency, cutting-edge* physical plant components for its chain of stores. The company wanted to try a number of cutting-edge energy-efficiency concepts for potential application in stores across the country. Therefore, their choice for the ENERGY STAR Showcase Building program was a store that needed to be completely refurbished. The 102,080-square-foot store in Fullerton was selected to provide actual operating experience with the selected concepts in a retail environment.

Exhibit 1—The Upgrades

Stage		Measures Implemented
1	Green Lights	<ul style="list-style-type: none"> • Relamp with T-8 lamps and electronic ballasts. • Install specular reflectors. • Delamp fixtures from 4-lamp to 2-lamp. • Use tandem wiring on ballasts. • Install occupancy sensors. • Convert to exterior high-pressure sodium lamps. • Add skylights (some capable of sun-tracking) for daylighting. • Install dimmable ballasts to maximize daylighting benefit.
2	Building Tune-Up	<ul style="list-style-type: none"> • Install new energy management system. • Clean fan blades. • Adjust dampers and diffusers. • Eliminate airflow restrictions.
3	Load Reductions	<ul style="list-style-type: none"> • Install reflective roofing. • Replace exterior doors. • Paint walls and ceiling light color. • Upgrade to higher efficiency kitchen equipment.
4	Air Distribution System	<ul style="list-style-type: none"> • Add variable-speed drive to main supply fan. • Add paddle fans in checkout area.
5	HVAC Plant	<ul style="list-style-type: none"> • Upgrade to staged rotary compressors. • Upgrade to water-cooled evap-condenser. • Add indirect evaporative cooling unit. • Add direct evaporative cooling unit. • Upgrade to higher efficiency rooftop units.

Upgrade projects were staged to allow the store to remain open throughout the construction. Original plans scheduled Green Lights upgrades and roof replacement to take place before the end of 1994. However, because of numerous delays resulting from heavy rains in the Los Angeles area, the lighting and cooling equipment upgrades did not begin until the middle of January 1995. Even though the construction schedule was very tight, the Grand Reopening celebration at the Target store was held on Earth Day—April 26, 1995.

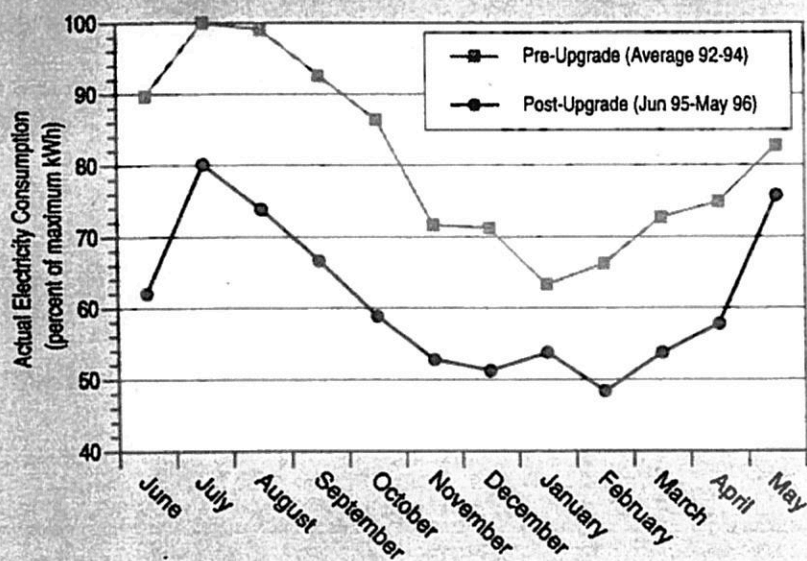
The team involved in the Target store upgrades included representatives from the local utility—Southern California Edison—and several equipment manufacturers. Southern California Edison provided Target with incentive funding to encourage upgrades to more energy-efficient equipment. A number of manufacturers were willing to provide equipment at discounted rates, and some

even donated equipment. Because of this cooperative effort to identify innovative energy-efficiency technologies that would be applicable to a retail facility such as Target, an exact financial cost analysis of the project is not available.

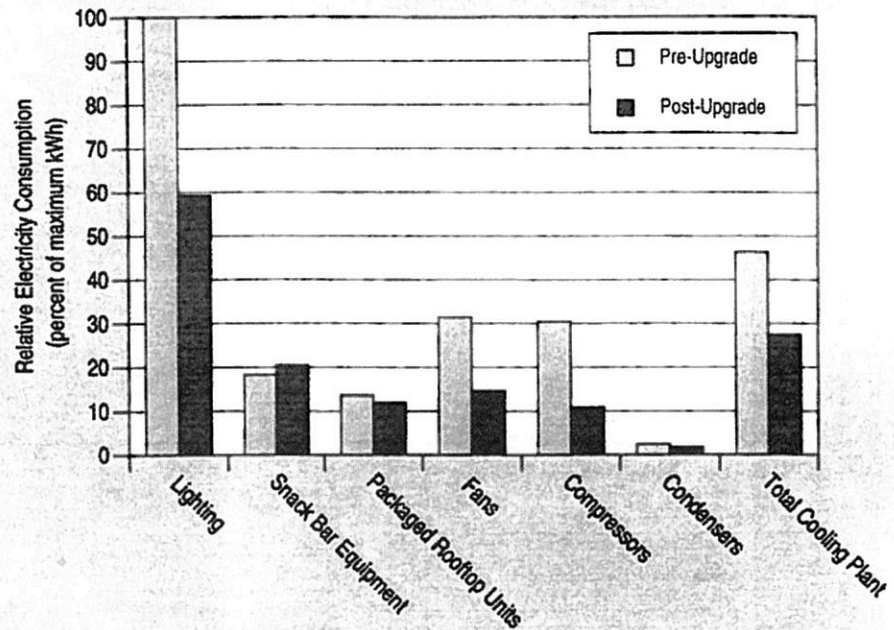
Electrical energy savings were confirmed by actual electric bills. Pre-upgrade electric use was based on an average of electricity consumed from January 1992 through December 1994. Post-upgrade energy use was analyzed from June 1995 through May 1996. Exhibit 2 displays the difference in energy use expressed as a percent of the maximum monthly kilowatthours consumed.

Through direct monitoring with kilowatt loggers connected at electrical panels, the percentage of energy saved by specific end-uses could also be quantified. Results are displayed in Exhibit 3.

Exhibit 2. Pre- and Post-Upgrade Monthly Electricity Consumption



**Exhibit 3. Change in End-Use Electricity Consumption
(Based on Direct Monitoring)**



Conclusions

Two important lessons were learned while the ENERGY STAR Buildings upgrades were being implemented at the Target Store.

1. Demonstrations of New Technologies Are Useful, and Customer Reaction Is Important. Because skylights had rarely been used in a retail environment, Target decided on a limited installation of this technology in order to determine how customers would react to the more natural lighting provided by skylights as opposed to the color rendition provided by artificial lighting. Customer reaction and Target's own operating experience have been positive, so skylights will be

used more widely in the company's future new construction and building retrofits.

2. Publicity and Outreach Help Reinforce the Goals of the Program. Target used a number of techniques to inform employees, customers, and the community about its participation in the ENERGY STAR Buildings program, including brochures (see Exhibit 4), posters, outdoor signs, promotional items, and press releases. Outreach tools such as these provide information about the work that is being done, promote the positive steps the building owner is taking to save energy and protect the environment, and help increase awareness of the importance of energy efficiency among the general public.

Exhibit 4. Brochure Distributed to Target's Customers



EPA



SHOWCASE BUILDING

Target was chosen by the EPA to be a part of their prestigious Energy Star Buildings Program. The Target Fullerton Store was the only store in California selected to participate in the program and will serve as an energy-saving model for Target nationwide.

Target retro-fitted the Fullerton Store with state-of-the-art systems that will reduce, reuse and recycle, meeting the EPA Energy Star Program goal of reducing energy use by nearly 50%. The Store will serve as an ongoing test-lab in our efforts to save energy, reduce pollution and preserve the environment.

We have upgraded hundreds of individual systems and areas inside and outside the Store, many of the changes are visible, but many are out-of-sight in areas like the roof, in the back rooms or above the ceiling.

Fullerton
2920 Yorba Linda Blvd.
Fullerton, CA 92631
(714) 579-3090

Key changes that you CAN see:

- Skylights to light part of the Store during daylight hours
- Dimming System to reduce the ceiling lighting during the day and return the lighting to it's full brightness during the evening.
- Food Avenue which has:
 - New energy efficient cooking equipment
 - New refrigerators and freezers which are both energy-efficient and utilize non-ozone depleting refrigerants
 - Table bases made from recycled engine block material
 - Tabletops made from flour and waste paper
 - Dining chairs made with recycled 35% plastic resin
- Ceiling Fans above the Check Lanes to provide cooling and reduce the need for as much air conditioning
- Upgraded Restrooms with features like:
 - Automatic water valves to reduce water usage
 - Motion detectors to turn on lighting only when it's needed
 - Paper towel dispensers to replace hand dryers
- Automatic Doors at the main entrance and to the Garden Center to save energy

Key changes that you CAN NOT see:

- Water-Reclamation System to re-use the water from the new air-conditioning system to water the plants in the Garden Center
- Solar Water Heater for all of the water needs in Food Avenue

Store-wide changes you CAN see:

New and Brighter Lighting inside accomplished by using:

- Electronic Ballast
- Smaller Lamps
- Mirror-like reflectors to focus more light where it is needed

Lighter Wall and Ceiling Color to eliminate the need for as much ceiling lighting.

Store-wide changes you CAN NOT see:

New Air-Conditioning System with:

- Non-ozone depleting refrigerants
- A feature that allows us to use water and outside air to cool the store

State-of-the-Art Computer System to operate and control all lighting and air-conditioning systems in the store, while maximizing energy consumption.

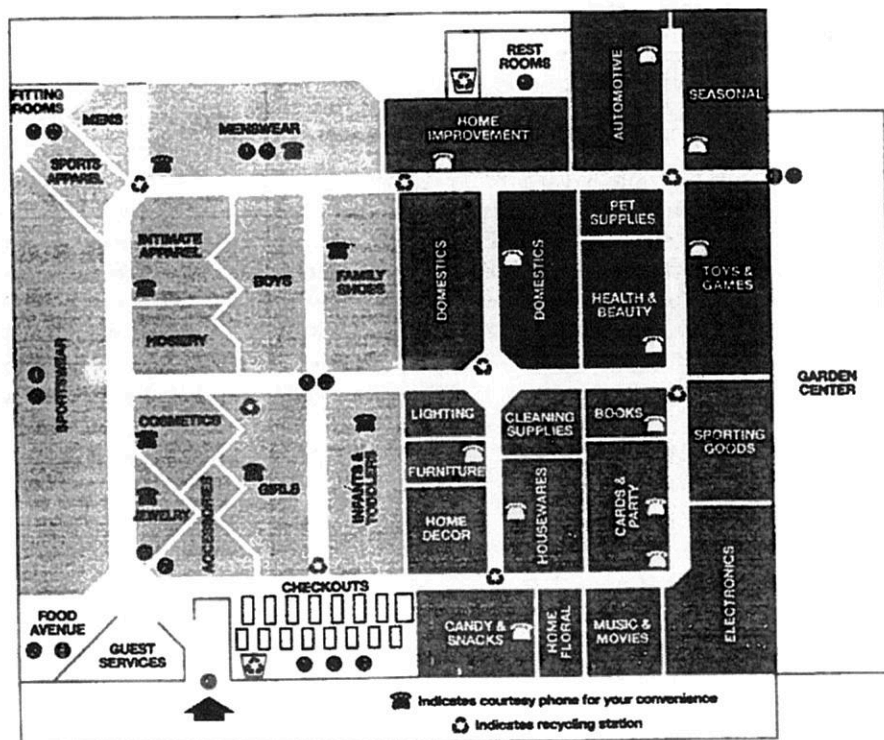
A White Roof to reduce the solar effects of the sun and thus reduce the energy needed to cool the building.

Target Stores' company-wide efforts over the past five years have saved enough energy to . . .

- Power every home in Fullerton for more than two years
- Power 60,000 American homes for one year
- Light 1 million light bulbs (50 watts), 24 hours a day, for 1 year

Target is a Good Neighbor!

Since we started business in 1962, 5% of our pre-tax income has gone back to the communities where we do business, more than any other retailer. In 1994, we gave over \$20 million back to our communities.



Pre-Upgrade Overview

Building in Brief

Function:

Retail

Age:

21 yrs.

Size:

102,080 sq. ft.

Location:

Southern California

Temperature Range:

30 to 101 degrees F.

Building Description

Target store 293 is located at 2920 Yorba Linda Boulevard in Fullerton, California. It was built in 1975 as a retail and grocery store prior to its purchase by Target in 1987. The 102,080-square-foot facility has four main areas:

- Retail sales floor (including the checkout area).
- Snack bar.
- Shipping and receiving area.
- Stock rooms.
- Offices.

An open-air garden department is adjacent to the structure. Exhibit 4 shows the layout of the store.

Target sells products ranging from clothing, toys, and sporting goods to hardware, office supplies, electronics, and garden supplies. With the exception of Thanksgiving and Christmas, the store is open to the public from 8:00 A.M. to 9:30 P.M., seven days a week. Employees work in various locations throughout the store from 6:00 A.M. to 11:30 P.M.

Climate

Annual temperature extremes in the Los Angeles area range from a maximum of 101 degrees F. to a minimum of 30 degrees F., with an average daily range of 20 degrees F. The design weather conditions recommended by the American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE) for use when determining the heating and cooling capacity requirements of equipment purchased for a building in the Los Angeles area are as follows:

- Winter dry-bulb temperature of 40 degrees F.
- Summer dry-bulb temperature of 89 degrees F. with 70 percent relative humidity.

Lighting

Most of the lighting in the Target store was provided by fluorescent lamps. The fixtures in the

main retail sales area were 4-foot fluorescent with 12-cell parabolic louvers. Each of these fixtures originally held four lamps. In other areas, such as offices, stock rooms, and wall soffits, and in areas with indirect lighting, fixtures held one or two fluorescent lamps. The lamps were 34-watt T-12 lamps with energy-saving magnetic ballasts.

The outside garden department adjacent to the store was illuminated by 6-foot fluorescent fixtures with two lamps. Exterior lighting was provided by 175-watt mercury vapor lamps and 40-watt incandescent lamps.

Air Distribution

The sales floor at the Target store was served by a supply fan running at 60,000 cubic feet per minute. Four packaged rooftop units served the perimeter areas: the store entry and checkout, the snack bar, the shipping and receiving area, and the offices. A small built-up unit on the roof served an area previously used as a grocery store.

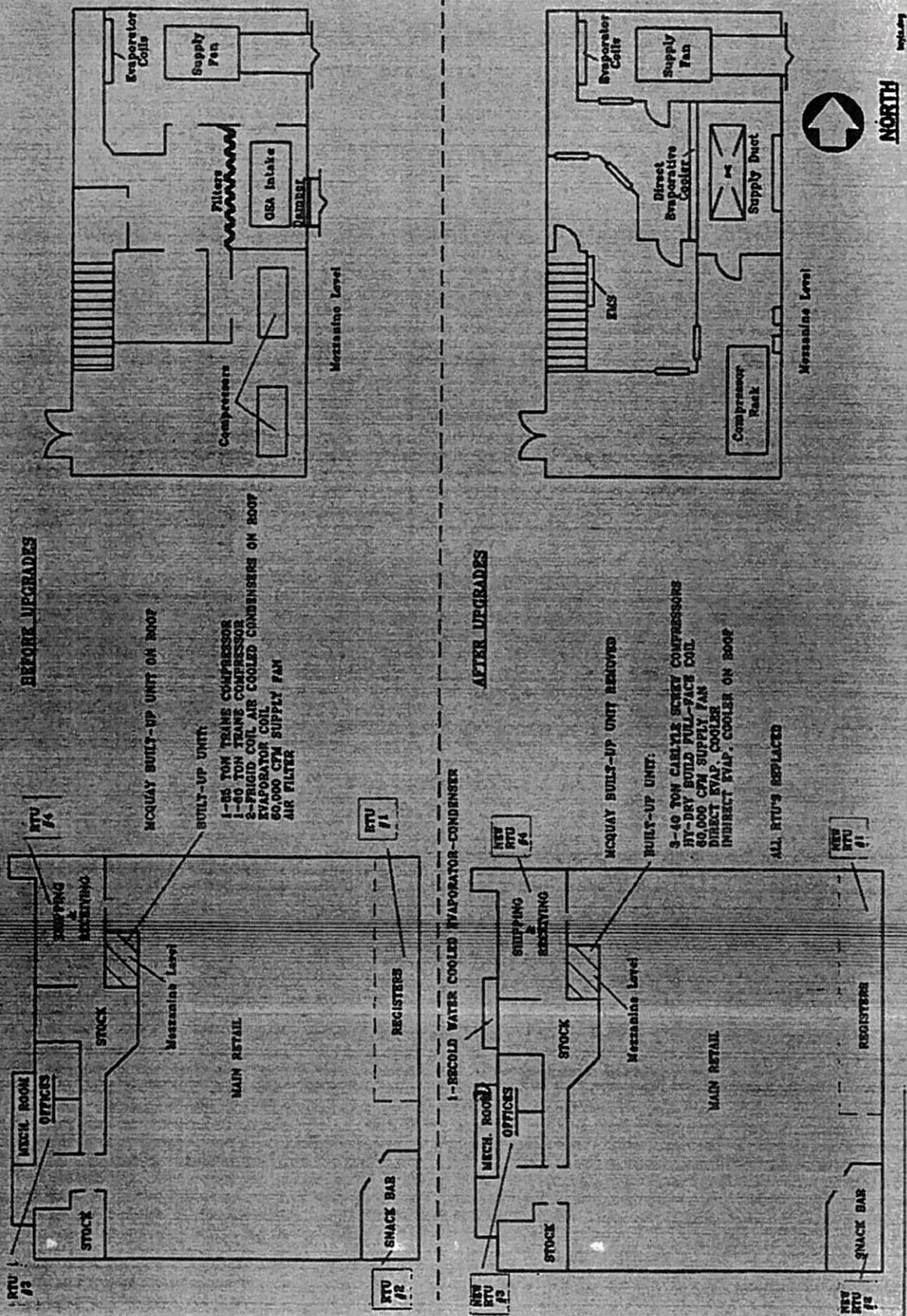
Cooling

The main retail area was cooled by a direct-expansion system that had two open-drive compressors with capacities of 85 tons and 60 tons. Heat was rejected by two air-cooled condensing units with total capacity of 2,736,800 Btu per hour. The unit that served the area previously used as a grocery store had 30 tons of cooling capacity.

Utility Rate Schedule

The electricity rate schedule determining the cost of electricity for the Target store is based only on the amount of energy used, not the time of day the energy is used. However, maximum demand at any one time does have an impact on the cost of electricity. For the maximum demand required

Exhibit 5. Floor Plan of Target Store



during a billing period, there is a constant distribution demand charge per kilowatt. In addition, during each billing period in the summer (June through September), a peak demand charge per kilowatt is added to the distribution charge.

The energy charge has two tiers:

- One rate for the first 300 kilowatthours consumed multiplied by the maximum kilowatt demand.
- A reduced rate for all kilowatthours beyond the first 300 kilowatthours.

In evaluating the cost-effectiveness of the energy-efficiency projects at the Target store, the focus was not only on reducing the energy consumption, but also on minimizing the electric power required at any given time (that is, demand reduction).

The store uses natural gas, but the quantity consumed each year is less than 1 percent of the amount of electricity consumed. Therefore, natural gas usage has not been included in the energy analysis for this Showcase building.

Energy Use Before Upgrades

Historical annual energy use for the Target store was determined from analysis of the electricity charges billed by Southern California Edison from January 1992 through July 1995. The "Before Upgrade" value was based on the 3-year average of energy used from 1992 through 1994.

Pre-upgrade energy costs per square foot at this store were 9 percent below the average cost for buildings in the Los Angeles area, but were 16 percent higher than those of newer Target stores built in the same area.

Energy End-Use

Energy consumption for the major building systems was determined from monitoring provided by Southern California Edison. Kilowatt loggers were attached to the electric panels to monitor energy consumption, as shown in Exhibit 6.

Exhibit 6—Energy Monitoring at the Target Store

Logger	Before Upgrade	After Upgrade
1	Main Sales Lights Rooftop Unit 4 Condenser Fan 2	Main Sales Lights Rooftop Unit 4 Condenser Fan 2
2	Compressor 1 Compressor 2 Air Handler 1 Condenser Fan 1	Indirect Evaporative Cooler Cooler Compressor Rack Air Handler Condenser Fan
3	Lighting Panel 2, 2-1 Lighting Panel 2 Water Heater	Lighting Panel 2, 2-1 Lighting Panel 2 Water Heater
4	Rooftop Unit 1 Rooftop Unit 2 Rooftop Unit 3 Kitchen Hood	Rooftop Unit 1 Rooftop Unit 2 Rooftop Unit 3 Kitchen Hood
5	Compressor 3 Air Handler 3 Condenser Fan 4	(a)

(a) Equipment measured by this logger was removed during upgrades.



Stage 1 Green Lights

Lighting in Brief

Upgrade Technologies:

T-8 lamps

Electronic ballasts

Delamp four-lamp fixtures to two lamps

Specular reflectors

Tandem wiring of ballasts

High-pressure sodium lamps

Skylights (some capable of sun-tracking) to incorporate daylight on retail floor and in shipping and receiving area and stock rooms

Occupancy sensors

Dimmable ballasts

Pre-Upgrade Lighting

Most of the lighting at the Target store in Fullerton was provided by fluorescent lamps. The fixtures in the main retail sales area were 4-foot fluorescent with 12-cell parabolic louvers. Each of these fixtures originally had four lamps. Fixtures in other areas, such as offices, receiving and marking rooms, and wall soffits, and in areas with indirect lighting, held one or two fluorescent lamps. The lamps were 34-watt T-12 lamps with energy-saving magnetic ballasts.

Exit signs in the store had 7-watt compact fluorescent lamps.

The front glass entry doors to the building were the only source of daylighting for the building's interior.

The outside garden department adjacent to the store was illuminated by 6-foot fluorescent fixtures with two lamps. Exterior lighting was provided by 175-watt mercury vapor lamps and 40-watt incandescent lamps.

Survey and Analysis

The lighting inventory at the Target store was conducted by a Southern California Edison team. Lighting upgrades recommended as a result of that survey included:

- Converting the T-12 fluorescent lamps to T-8 lamps with electronic ballasts.
- Converting the incandescent lamps to compact fluorescent lamps.
- Changing the 175-watt mercury vapor lamps to 100-watt high-pressure sodium lamps.

Since there was virtually no natural lighting provided to the interior space, the addition of skylights was an opportunity to reduce electric lighting requirements. Application of daylighting in the shipping and receiving area and stock rooms was an easily accepted possibility. However, since

retail businesses have traditionally considered artificial lighting to provide the color rendition most acceptable to customers, the addition of skylights in the sales area required more extensive discussions. The final decision was to try skylights in part of the sales area to determine how shoppers would react to natural light in the store.

Lighting levels were not changed, because the original illumination in the store was within the Illuminating Engineering Society (IES) recommended range for a retail facility. With the possible addition of skylights, the inclusion of dimmable ballasts in the sales floor lighting would provide the ability to reduce the electric lighting in response to the available natural light.

Implemented Upgrades

Exhibit 7 provides a summary of the lighting fixtures at the Target store in Fullerton before and after the Stage 1 lighting upgrades.

The following nine lighting projects were undertaken at the Target store:

- Replace existing 34-watt T-12 lamps with 32-watt T-8 lamps.
- Replace existing standard magnetic ballasts with electronic ballasts.
- Delamp four-lamp fixtures to two lamps.
- Add specular reflectors.
- Tandem wire ballasts, where possible.
- Convert 175-watt mercury vapor lamps to 100-watt high-pressure sodium lamps.
- Add skylights to incorporate daylight on retail floor and in the shipping and receiving area and stock rooms.
- Add occupancy sensors in bathrooms, offices, the shipping and receiving area, and stock rooms.
- Add dimmable ballasts to allow reduction of lighting levels to gain maximum benefit from skylights.

The configuration of skylights on the retail sales floor included the following:

- 40 sun-tracking skylights for the south and west sides.
- Four, 4 x 4 fixed skylights in the center.
- A single 4 x 4 fixed skylight over the jewelry counter.
- Four 4 x 4 fixed skylights over the checkout area.

Diffusing lenses that give the appearance of a standard electric lighting fixture were chosen for the sun-tracking skylights in the sales areas. Fernsnel (circular diffraction) lenses were used for the large skylights in the center of the store and the smaller skylight over the jewelry counter to diffuse incoming light and prevent direct sun rays from entering the store.

The shipping and receiving area and stock rooms were provided with six 4 x 4 skylights and five

4 x 8 skylights. These skylights used clear glass without any lenses.

Conclusions

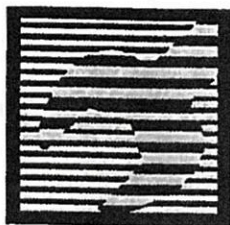
Calculations comparing the connected load of the original lighting with the projected upgrades predicted a 46-percent reduction in watts per square foot at the Target store in Fullerton. Since implementation of the Stage 1 lighting upgrades, analysis of kilowatt logger data for the main sales floor indicate actual electrical energy savings of 41 percent.

Customer reaction and Target's operating experience with Green Lights have proven the lighting retrofit to be an excellent energy-saving upgrade. Future remodeling of other Target stores will not only repeat the skylights installed at the Fullerton store, but will increase the number of skylights to cover the entire sales floor.

Exhibit 7—Lighting Fixtures at Target Store Before and After ENERGY STAR Upgrades

Lighting Fixtures		Before Upgrade			After Upgrade		
Type	Quantity	Lamp Type	Lamp Wattage	Ballast Type	Lamp Type	Lamp Wattage	Ballast Type
Fluorescent	1,047	T-12 Energy Saver	34	Energy Saver	T-8	32	Electronic 0.90
Fluorescent	200	T-12 Energy Saver	75-110	Energy Saver	T-8	64	Electronic 0.90
Incandescent	28	Incandescent	40	—	Incandescent	40	—
Incandescent	5	Incandescent	100	—	(These Fixtures Were Eliminated)		
HID Low Bay	33	Mercury Halide	70	HID Magnetic	(These Fixtures Were Eliminated)		
Wall Pack	33	Mercury Vapor	176	HID Magnetic	High-Pressure Sodium	100	HID Magnetic
Exit Signs	21	CF	9	Magnetic	LED	7	—

Note: Table based on Target Store Lighting Inventory data obtained from Southern California Edison in August 1994.



Stage 2 Building Tune-Up

Tune-Up in Brief

Upgrade Technologies:

Clean fan blades

Adjust dampers and diffusers

Eliminate airflow restrictions

New energy management system

Stage 2 of the ENERGY STAR Buildings Program concentrates on opportunities to make a building more energy-efficient through preventive maintenance and modifications to existing equipment and procedures. Many of these improvements are no-cost or low-cost and therefore profitable on their own; however, they also create a solid foundation for the energy-efficiency investments in Stages 3, 4, and 5, making these investments even more profitable.

Survey and Analysis

Problem areas identified during the Stage 2 Building Tune-Up survey at the Target store in Fullerton included the following:

- Doors allowing excessive air infiltration.
- Sagging roof insulation.
- Inoperative economizer dampers.

In addition, a system test and balance provided the following observations on the supply fan in the retail sales area:

- Fan bearings appeared to be adequate, but fan blades had an excessive build-up of dirt.
- Mixed-air dampers did not appear to operate and allowed approximately 15-percent leakage when fully closed.
- Diffusers were out of adjustment or closed.
- Relief dampers remained partially open when the supply fan was running on 100-percent return air.
- The mezzanine area used as a return air plenum was poorly sealed and restricted airflow.

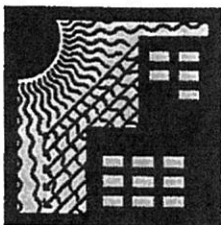
The doors were addressed as part of the Stage 3 load-reduction upgrades. Adjustments to the plenum, dampers, and diffusers were combined with installation of new HVAC equipment in Stage 5.

Instead of *recommissioning* the existing mechanical system in a Stage 2 tune-up, an initial commissioning of the new mechanical equipment was conducted after construction was complete to ensure that the system was working at peak efficiency.

Another major component of Stage 2 is establishing a preventive maintenance program to ensure that mechanical systems continually operate in a tuned-up condition. Target implemented an extensive preventive maintenance program with the installation of a new energy management system. This system became part of a nationwide system that allows Target to monitor controls at a number of stores from the company's central office. This strategy allows trained staff at the central office to manage the costs of utilities, monitor the comfort of store environments, and diagnose problems at individual stores. The new energy management system that implements this strategy also provides operating information at the building that contractors can use in conducting routine maintenance or when responding to emergencies. The new system has the ability to control the operation of the lighting and to select the best operating mode for the cooling system based on the outside weather conditions.

Conclusions

As operating experience is gained with the new system, building commissioning activities continue to be addressed as part of the ongoing Stage 2 program. For example, filter media that were not originally included in the HVAC system upgrade have been installed because debris was building up on the direct evaporative cooling coil. This could have led to restricted airflow and increased fan energy use.



Stage 3 Other Load Reductions

Load Reductions in Brief

Upgrade Technologies:

Reflective roof covering
Automatic bifold doors with
improved sealing capability
Light-colored paint on
interior walls and ceiling
Energy-efficient kitchen
equipment

Stage 3 of the ENERGY STAR Buildings Program looks at upgrades that will reduce the heating and cooling loads in a building. Cooling loads are lowered by reducing solar gain through the roof and windows or reducing internal heat gains with more energy-efficient equipment. The following load reductions at the Target store reduced the heat gain to the interior space:

- A new, white, single-ply roof membrane was installed over the existing insulation to replace the deteriorated roof. The white color reduces the solar effects of the sun on the building, which in turn reduces the cooling required. Adding more insulation as part of this upgrade would not have been cost-effective.
- New automatic bifold glass doors with improved sealing capability were installed at the front of the store and at the access to the outside garden department, minimizing the entry of unconditioned outside air. However, given the mild California weather, a second set of doors to act as an airlock at the entry would not have been cost-effective.

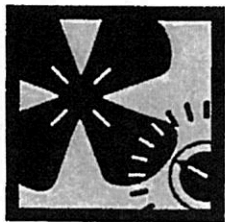
- The interior walls and ceiling were painted a lighter color to reduce lighting requirements, which in turn lowered the heat added to the interior space from unnecessary lighting.

Target wanted to increase the number of menu selections available in the Food Avenue food-service area. In addition to the additional floor space required, Target purchased the following new equipment to accommodate this expansion:

- Energy-efficient cooking equipment.
- Energy-efficient refrigerators and freezers that also used environmentally friendly refrigerants.
- Solar water heater.

Target's choice of energy-efficient equipment for Food Avenue led to significant cost avoidance.

By implementing these load reductions, the mechanical equipment purchased for the HVAC plant could be of smaller capacity, further reducing the building's energy requirements.



Stage 4 Air Distribution System

Air Distribution in Brief

Upgrade Technologies:

Variable-speed drive for supply
fan serving sales area

Paddle fans in checkout area

Pre-Upgrade Conditions

Air distribution for the main sales floor at the Target store in Fullerton was provided by a 60,000-cubic-feet-per-minute constant-volume supply fan. A small built-up unit on the roof served the area used by the original occupant of the building for groceries.

Survey and Analysis

The system test and balance report conducted as part of Stage 2 indicated that only 47,500 cubic feet per minute of airflow was required for the retail area, but that 51,117 cubic feet per minute was being supplied. Complaints had been received in the store regarding drafts and cold temperatures in the dressing rooms.

Variable-speed drives would reduce airflow to the required amount and provide the ability to adjust airflow according to conditions, providing energy savings and improving comfort levels.

Implemented Upgrades

A variable-speed drive was added to the motor of the retail sales area supply fan so that air volume can be adjusted to the amount needed to meet ventilation and cooling requirements. The reduction of fan speed reduces energy consumption and also minimizes peak electric demand.

The need for additional air distribution in the checkout area—caused by the higher density of people and the unavoidable infiltration of outside air from the entry doors—was met with the addition of paddle fans to increase circulation.

Conclusions

Since the implementation of Stage 4 air distribution system upgrades at the Target store, fan energy consumption has been reduced 53 percent, as monitored by kilowatt loggers connected to the electrical panels over two comparable 62-day periods.



Stage 5—HVAC Plant

HVAC Plant in Brief

Upgrade Technologies:

Staged rotary compressors
Water-cooled evap-condenser
Indirect evaporative cooling
Direct evaporative cooling
More efficient rooftop units

Pre-Upgrade Conditions

The main retail area at the Target store was cooled by a built-up unit comprised of two open-drive compressors with capacities of 85 tons and 60 tons, respectively. Heat from the four-section evaporator coil was rejected by two 20-year-old air-cooled condensing units with a capacity of 2,736 kBtu per hour. A smaller built-up unit with a 30-ton compressor and air-cooled condensing units served the shipping and receiving area and the portion of the retail area that had previously been a grocery store. Perimeter areas, including the entry and checkout area, the snack bar, stock rooms, and offices, were served by four packaged rooftop units.

Survey and Analysis

All of the existing HVAC cooling equipment at the Target store needed to be replaced. State-of-the-art systems that would provide significant reductions in energy use were identified to replace the existing equipment. Selection criteria for new units also included use of environmentally friendly refrigerant.

The smaller built-up unit would be removed from the system.

Implemented Upgrades

The rooftop units were replaced with four new packaged units using a new type of refrigerant, a ternary mixture of HFC-32, HFC-125, and HFC-134a that offers performance and safety characteristics comparable to those of HCFC-22.

Redesign of the system serving the main retail area included the following new equipment:

- Rack assembly with three 40-ton rotary compressors using HFC-134a as the working refrigerant.

- Refrigerant evaporator with a three-circuit, full-face, four-section coil.
- Indirect evaporative cooling unit with a 50-horsepower fan motor, to provide free cooling to incoming air from moisture evaporation by the warm exhaust air.
- Direct evaporative cooling unit to provide free cooling by removing heat from the supply air through direct evaporation of water flowing across the coils.
- Water-cooled evap-condenser (92-degree design) with a linear kinetic cell piped in line with the circulating water pump to control scale buildup.
- Liquid pressure amplifier system consisting of a centrifugal pump placed in the liquid line between the accumulator and expansion valve to improve the efficiency of the refrigeration cycle. Energy is saved by:
 - Eliminating the need for controls to suppress the formation of flash gas. Controls are normally required to ensure that adequate refrigerant pressure is maintained in the condenser and ahead of the expansion valve.
 - Allowing compressor head pressure to float downward with the decreasing ambient temperature, improving the overall thermodynamic efficiency of the vapor-compression system.
 - Reducing compressor operating time.

The sequence of equipment operation for cooling in the retail area begins with the indirect evaporative cooling unit. When needed, the rotary compressors are added one at a time to meet the load demand. The direct evaporative cooling unit has on-off control and is used as appropriate. Exhibits 8 and 9 contain schematics of the HVAC plant flow before and after the upgrades.

Implementation of these upgrades produced an overall 40-percent reduction in HVAC plant energy use at the store.

Exhibit 8. Schematic of HVAC Plant Before ENERGY STAR Upgrades

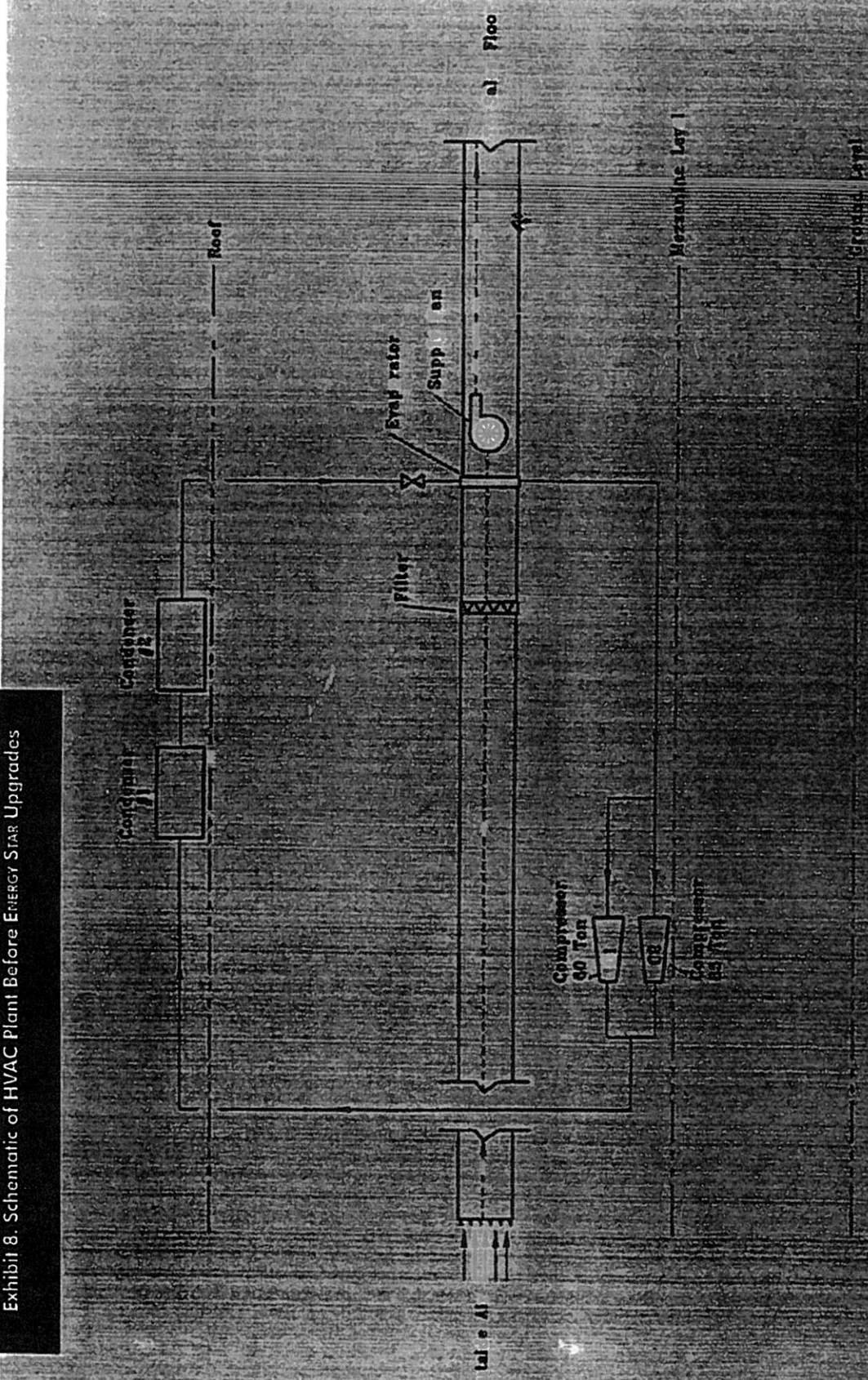


Exhibit 9. Schematic of HVAC Plant After Energy Star Upgrades

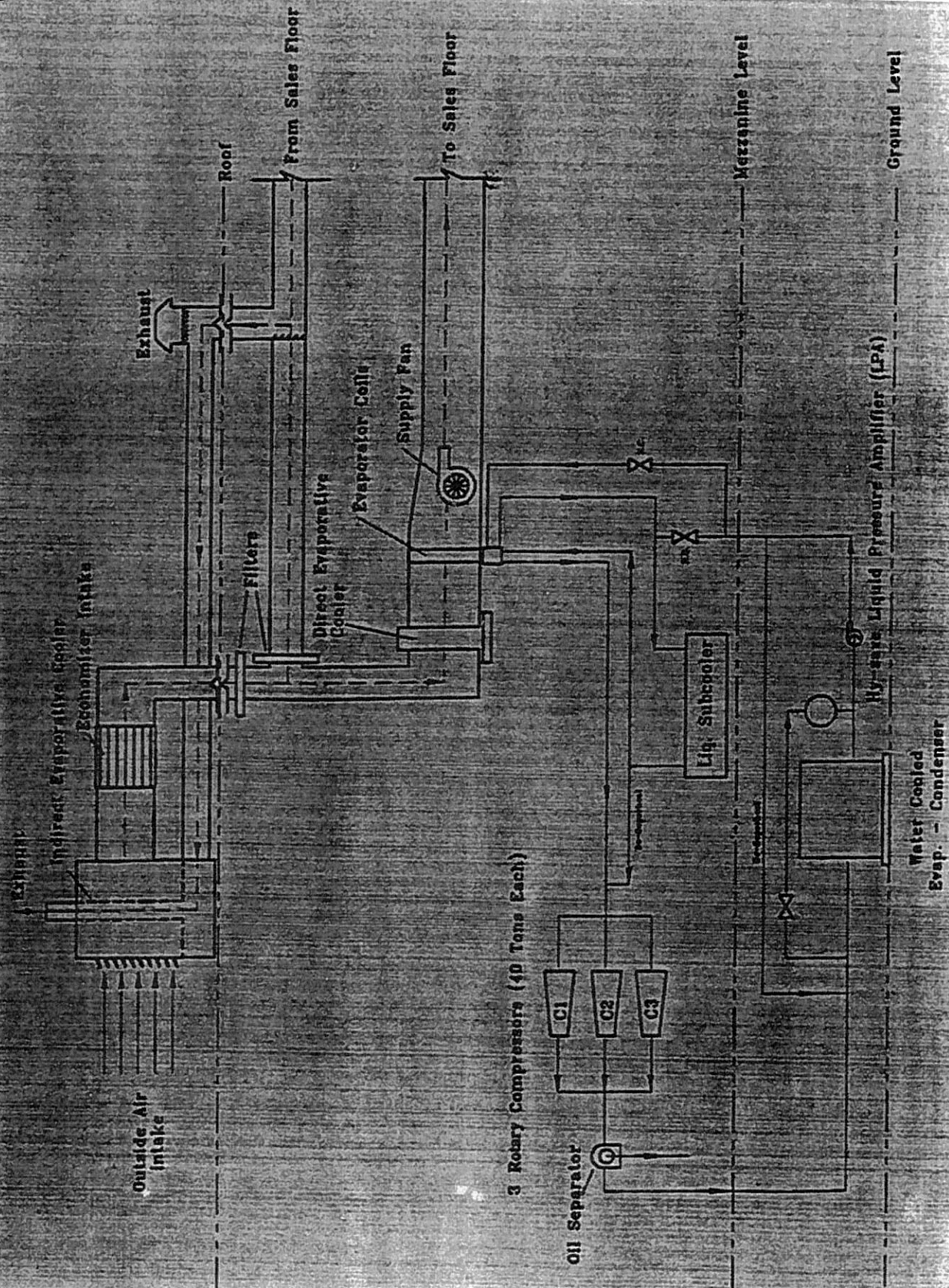


Exhibit 10 shows the percent difference in monitored energy use by the individual components before and after the upgrades. The energy savings were determined from data collected over two comparable 62-day periods with kilowatt loggers connected to the electrical panels. The indirect evaporative cooler was a new piece of mechanical equipment that did add to the electrical load. However, the energy savings provided by improvements over the original equipment resulted in overall savings for the HVAC plant.

Conclusions

Commissioning the new equipment was beneficial for Target because it helped building engineers identify areas that needed adjustment.

The first major issue was an oil pump seal leak. The alarms worked as designed and provided an appropriate warning that allowed the problem to be addressed in a timely manner. A minimal quantity of R-134a refrigerant was released. The leak resulted from an incompatibility of the original seal material with R-134a. The seal was replaced with a compatible material.

Another issue was the failure of the humidistat monitoring the supply air. The energy management system did not receive an elevated humidity

Exhibit 10—Results of Upgrades

Equipment	Energy Savings
Compressors	64%
Condensers	26%
Rooftop Units	13%
Indirect Evaporative Cooler	(new equipment)
Total HVAC Plant	40%

reading that would have removed the direct evaporative cooling unit from service. As a result, humidity in the retail area increased above the comfort level. Humidity control of the supply air remained a problem. Operation of the direct evaporative cooling coil was allowing extensive carry-over of water vapor, creating extremely high humidity in the retail area. The cooler was drained and removed from service until a solution could be identified.

Continued operating experience will determine the suitability of similar upgrades for additional Target stores.

Overall Results

Based on 12 months of post-upgrade utility data from June 1995 through May 1996, the ENERGY STAR upgrades reduced annual electricity consumption by 24 percent and electricity costs by 32 percent. Before implementation of the upgrades, the store consumed 20 percent less energy than the average retail store in the Los Angeles area. After the upgrades, the energy consumption was 40 percent below the area average.

Data obtained from the loggers directly monitoring electricity use at the store allowed a comparison of energy consumption by specific end-uses. Monitored data for the four billing periods before the upgrades were averaged to duplicate the 2-month period monitored after the upgrades.

As is typical in retail buildings, the greatest quantity of electricity continues to be consumed for lighting, but the ENERGY STAR upgrades have reduced that consumption by 15 percent. Upgrades to cooling and ventilation equipment, the second greatest electricity consumers, also produced a 15-percent reduction. Individual components displaying the largest change were the compressors, with an 11-percent decrease, and the fans, with a 9-percent decrease. The reduction in compressor energy use was a result of more efficient equipment combined with reduced operating hours. Even though the fans

on the indirect evaporative cooler were new energy users, that system has been very effective in providing "free" cooling, which minimizes the requirement for mechanical cooling.

The reduction in electrical energy used by the Target store in Fullerton can be converted to a reduction in air pollution emitted from electric generation stations burning fossil fuel. Exhibit 11 summarizes the quantity of carbon dioxide, sulfur dioxide, and nitrogen oxides prevented from entering the atmosphere as a result of the ENERGY STAR upgrades.

The good results and lessons learned from this project will help Target as it incorporates new approaches and technologies to further reduce energy costs in other stores around the country.

Exhibit 11—Pollution Prevented

Pollutant	Amount
Carbon Dioxide	409,596 lb/yr
Sulfur Dioxide	993 lb/yr
Nitrogen Oxides	1,354 lb/yr

